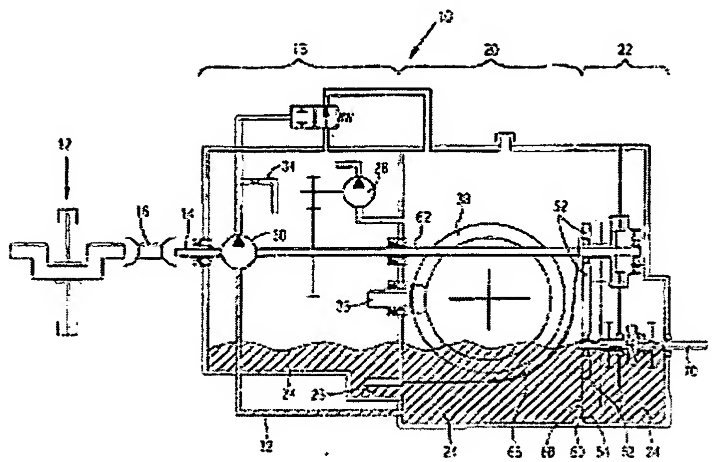

(57) Abstract: The invention relates to a gearbox arrangement (10) for a vehicle, preferably an industrial or agricultural goods vehicle. The gearbox arrangement (10) can be at least partially lubricated with lubricant (24) from a lubricant sump and comprises at least two gearbox sections (20, 22). Each gearbox section (20, 22) comprises a gearbox housing part (44, 46). The gearbox housing parts (44, 46) of the two gearbox sections (20, 22) are adjacent to each other and form part of a lubricant sump. In a normal operational mode, one or the other gearbox section (20, 22) can normally be operated. According to the invention, a separating means (42) is provided between the two gearbox sections (20,22) in order to reduce losses occurring in the gearbox arrangement (10) due to splashing for at least in most operational states of the vehicle, without substantially increasing the amount of construction space provided for the gearbox arrangement (10), said separating means being used to separate the two gearbox sections (20, 22) from each other in an at least partial manner. Lubricant (24) can be retained in the housing part (44,46), whereby the gearbox section (20,22) thereof is not operated in a momentary state of operation or operated at a low speed.

The present invention relates to a gearbox arrangement for a vehicle. Preferably, the vehicle is an industrial or agricultural utility vehicle. The gearbox arrangement can be lubricated at least partially with lubricant from a lubricant sump. The gearbox arrangement has at least two gearbox sections. Each gearbox section has a gearbox housing part, with the gearbox housing parts of the two gearbox sections being adjacent to each other and forming a part of the lubricant sump. In particular, in the normal operating mode, typically either one or the other gearbox section can be operated.

Gearbox arrangements of the type described above have been known for a long time from the state of the art. For example, gearboxes of the applicant, which are used for tractors, have several gearbox sections, which are directly adjacent to each other and which form a lubricant sump. A gearbox section in the sense of the present invention is understood, in particular, to be a functional section of a gearbox, for example, the differential gearbox section or the power take-off gearbox section. A gearbox housing part in the sense of the present invention is understood to be, in particular, the part of the overall gearbox housing, which holds a gearbox section. A gearbox housing part does not necessarily have to be able to be disassembled from another gearbox housing part or it can be configured in two or more parts; the gearbox housing parts can also consist of one continuous part. Typically, gear oil is used as the lubricant. In another gearbox section - which has, for example, a power-shift gearbox - spatially separated from the gearbox sections, there is an air pump. In the driving mode of the vehicle, the air pump operated at this time has the effect that lubricant located in

the other gearbox section - specifically, in a differential gearbox and a power take-off gearbox - is fed through a corresponding lubricant channel into the gearbox sections.

This produces an elevated lubricant level in the power take-off gearbox area and in the differential gearbox area of the drive train, and thus in the other gearbox sections, which leads to increased splashing losses in the differential gearbox area of the gearbox arrangement, especially at high driving speeds. Here, the efficiency of the gearbox arrangement is disadvantageously reduced primarily at high driving speeds.

Now, an additional housing part could be provided, in which the lubricant - for example, at high driving speeds of the vehicle - could be housed, like the housing part, for example, in

DE 1 801 917. Housing the lubricant in the additional housing part is achieved in DE 1 801 917 such that there is a ring gear immersed in the lubricant sump, with which the lubricant is thrown upwards in the tangential direction and guided into this additional housing part after reflecting off the upper gearbox housing wall. However, this additional housing part requires additional installation space, which is not available without further measures.

Therefore, the present invention is based on the task of providing and improving a gearbox arrangement of the type described above, through which the previously mentioned problems can be overcome. In particular, splashing losses of the gearbox arrangement should be reduced at least in most operating states of the vehicle, wherein the installation space provided for the gearbox arrangement should not be increased significantly.

The task is accomplished according to the invention by the teaching of Claim 1. Additional advantageous configurations and improvements of the invention emerge from the subordinate claims.

According to the invention, a gearbox arrangement of the type named above is characterized in that between the two gearbox sections there are separating means, with which the two gearbox sections can be separated from each other at least partially. Here, lubricant can be retained in the gearbox housing part whose gearbox section is inactive or operated at a lower rpm in the current operating state.

According to the invention, it was initially recognized that an additional housing part is not required as a storage reservoir for the lubricant, because the gearbox section, which is inactive or only in minimum operation in the current operating state of the vehicle, can be used as a storage reservoir for the lubricant by means of the separating means. Here, the lubricant level in the gearbox section, which is operated at a high rpm in the current operating state of the vehicle, is reduced or decreased, whereby, in an extremely advantageous way the splashing losses can be considerably reduced at least in terms of this gearbox section. Because no additional housing part is to be provided as a storage reservoir, the installation space for the gearbox arrangement according to the invention does not have to be increased. Here, the lubricant can be thrown from the gearbox section operated at a higher rpm, for

example, by a ring gear immersed in the lubricant sump in the direction of and/or by means of the separating means to the other gearbox section. Accordingly, in this example of the indirect housing of the lubricant, no additional pumps or similar means are to be provided in order to bring the lubricant directly and/or actively from one gearbox section into the other gearbox section. The separating means cause a separation of the surfaces of the two gearbox sections. Here, above all, the quantity of lubricant to be stored can be reduced significantly relative to a desired lubricant level reduction in one of the two gearbox sections.

In a preferred embodiment, the separating means have a separating wall. This separating wall is provided between the two gearbox sections and extends preferably from the base of the gearbox housing part upwards, but not up to the upper, inner gearbox housing wall of a gearbox housing part. In this respect, the two gearbox sections are connected in terms of air via the remaining gap or via the remaining opening. Through the remaining gap or the remaining opening, the lubricant can also be thrown into the other gearbox section with the help of a ring gear, which is immersed in the lubricant sump and which rotates during operation.

In an especially preferred way, the separating wall extends from the base of the gearbox arrangement to at least the height of a gearbox input shaft or gearbox output shaft in one of the gearbox housing parts. In particular, one gearbox section could be formed as a differential gearbox and the other gearbox section as a power take-off gearbox. In this case, the separating wall extends from the base of the gearbox arrangement approximately to the height of the drive shaft of the power take-off shaft. If necessary, the separating wall could also be formed even higher, especially if the volumes of the two gearbox sections used for the lubricant differ significantly. In this case, it should be possible that due to the high separating wall, the gearbox section with the smaller spatial volume percentage can retain a larger quantity of lubricant, which typically can be stored in the gearbox section with the larger volume percentage. If the separating wall extends with its upper end over the drive shaft of the power take-off shaft, a recess or a bore could be provided for the drive shaft of the power take-off shaft in the separating wall.

If necessary, the separating wall could have a sealing means, with which the separating wall can be sealed against the gearbox input shaft or gearbox output shaft, that is, if the upper edge of the separating wall lies above the gearbox input shaft or gearbox output shaft. Here, a possibly undesired backflow of the lubricant through the intermediate space between the corresponding gearbox shaft and the separating wall can be reduced or avoided.

In one especially preferred embodiment, the separating means can be sealed against a gearbox housing part with the help of additional sealing means. For example, the separating means could be formed by an already existing bearing plate optionally in connection with one or more additional wall sheet part(s) supporting the front bearing positions of a power take-off shaft gearbox. Sealing the bearing plate or the wall sheet part relative to the base and

the side walls of the gearbox arrangement could be realized, for example, with the help of elastic spring steel strips, wherein the spring steel strip or strips is or are fixed on one side to the bearing plate or to the wall sheet parts and on the other side contact a beveled area on the housing wall of the gearbox arrangement. Instead of the spring steel strips, sealing elements made from rubber or plastic could also be used. Here, an airtight partitioning between the two gearbox sections is not achieved, but this is also not absolutely required, because the portion of the lubricant which is led from one gearbox section to the other gearbox section due to possible unsealed sections of the additional sealing means is negligible with respect to the portion of the lubricant, which is fed, for example, by a rotating ring gear from one gearbox section to the other gearbox section. In an especially advantageous way, through the presence of spring strips, the requirements on the production tolerances of the cast or sheet parts can be held to a minimum, which enables economical production of the gearbox arrangement according to the invention.

In an especially preferred way, the separating means is formed such that more than half of the lubricant typically found in the two gearbox sections can be retained in one of the gearbox housing parts. In particular, the separating means could be realized not only by a flat separating wall, but instead through a corresponding formation that could extend into the part of a gearbox section which is not obstructed by gearbox components. In this respect, the separating means can separate the interior volume of the two adjacent gearbox sections from each other into a different geometric shape than could be defined, for example, by the housing of each gearbox section. Preferably, the separating means are formed such that approximately half to 2/3 of the volume of the lubricant typically found in the two gearbox sections can be retained in one of the two gearbox sections.

Basically, one part of the lubricant could be brought out of the gearbox section operating at a higher rpm into the other gearbox section - so to speak, actively - with the help of lubricant pumps, air pumps, or the like. In this way, for example, lubricant level control could be realized. Preferably, however, these components are provided in a gearbox arrangement which produces additional costs in production. Therefore, in an especially preferred way, at least one guidance means is to be provided in a gearbox housing part, with which the lubricant thrown from one rotating gearbox part - for example, a ring gear - arranged in one gearbox housing part can be guided into the other gearbox housing part. According to this advantageous embodiment, the lubricant is led from one gearbox section to the other due to the throw-off effect of a rotating gearbox part. The presence of guidance means can improve or optimize the conveyance effect. As guidance means, a guide plate could be provided, which is fixed near the base of the gearbox arrangement, for example, on the gearbox housing, and which is arranged at least partially concentric to the rotating gearbox part. Another guidance means could be formed by an arc-shaped guidance sheet, which is arranged on the upper housing wall of the gearbox arrangement and which reflects

or guides a lubricant fluid stream coming diagonally from below from one gearbox section at a given angle into the other gearbox section.

In an especially preferred embodiment, return means are provided, with which lubricant can be returned from one gearbox housing part to the other gearbox housing part. In the simplest case, the return means are arranged on the separating means - especially in the area near the base - and are preferably realized in the form of a through hole. The diameter of the through-hole is dimensioned such that the return flow of the lubricant from the gearbox section with the higher lubricant level is not too slow, so that there is always a sufficient quantity of lubricant in the gearbox section operated at a higher rpm, so that these gearbox components are lubricated sufficiently and simultaneously a secure suctioning of lubricant from the lubricant sump by the lubricant pump is guaranteed under all operating conditions. On the other hand, the return flow of the lubricant from the gearbox section with the higher lubricant level should not be too fast, so that the splashing losses in the gearbox section operated at a higher rpm do not become too large. As return means, a lubricant channel, in which the lubricant could be fed into the other gearbox section - under some circumstances also with a lubricant pump - in the gearbox arrangement would also be conceivable.

In this way, a dynamic lubricant or oil level control is possible, which operates, with suitable formation and dimensioning of the separating means, as well as the return means, in a somewhat self-controlled way.

As already indicated, in particular, one gearbox section could have a differential gearbox and the other gearbox section could have a power take-off gearbox, as can be the case, for example, in gearbox arrangements for agricultural utility vehicles of the applicant. At high driving speeds, the differential gearbox is operated at a high rpm, so that the lubricant is thrown from the differential gearbox into the power take-off gearbox. If the driving speed is reduced and the power take-off shaft is activated, the differential gearbox is operated at a lower rpm, but the power take-off gearbox is operated at a higher rpm. In this case, the lubricant found in the power take-off gearbox is thrown into the differential gearbox. In both cases, the return means ensures that a predetermined quantity - under some circumstances a small quantity - can flow from one gearbox section back into the other gearbox section. In this way, a dynamic lubricant level control is realized, which is especially advantageous when the agricultural utility vehicle has a high driving speed, for example, 50 km/h. In this case, the lubricant is thrown from the differential gearbox into the power take-off gearbox, so that here nearly no splashing losses occur and approximately 4 kW power loss can be avoided in the gearbox drive train. If the agricultural utility vehicle operates in power take-off mode, the driving speed typically equals only a few km/h, so that nearly no splashing losses occur in the differential gearbox operated at a lower rpm. In contrast, the power take-off gearbox operated at a higher rpm throws the lubricant into the differential gearbox, so that slight splashing losses occur in the power take-off gearbox. For the case of a power take-off mode

at high driving speeds of the utility vehicle, splashing losses can occur, which, however, also cannot be avoided in conventional gearbox arrangements of this type without additional structural measures. It has been shown by measurements that the power take-off mode at a 50 km/h driving speed exhibits power losses to be traced back to splashing losses even with the gearbox arrangement according to the invention, but in contrast the power losses in the differential gearbox decrease significantly, so that a reduction of power losses is to be noted by the gearbox arrangement according to the invention in an especially advantageous way in the overall balance.

Now there are various possibilities to reduce to practice and refine the teaching of the present invention advantageously. On one hand, reference is made to the claims below Claim 1 and on the other hand, reference is made to the following description of the preferred embodiments of the invention with reference to the drawing. In connection with the description of the preferred embodiments of the invention with reference to the drawing, generally preferred configurations and improvements of the teaching are also explained. Shown in the drawing, each in a schematic view, are

Figure 1, in a side view, a first embodiment of a gearbox arrangement according to the invention in a first operating state of the vehicle,

Figure 2, in a side view, the embodiment from Figure 1 in a second operating state of the vehicle,

Figure 3, in an enlarged side view, two gearbox sections of the embodiment according to the invention from Figures 1 and 2 in the second operating state of the vehicle,

Figure 4, in a side view, the two gearbox sections from Figure 3 in a third operating state of the vehicle,

Figure 5, in a side view, the two gearbox sections from Figure 3 in a fourth operating state of the vehicle,

Figure 6, in a plan view, the two gearbox sections from Figure 3,

Figure 7, in a perspective view, individual components of the two gearbox sections from Figure 3, and

Figure 8, a section view of a part of the separating means, which is sealed with a sealing means against the inner side of the gearbox housing.

The same or similar components are designated with the same reference symbols. Figure 1 shows a gearbox arrangement 10 of a vehicle not shown in more detail in Figures 1-8. The gearbox arrangement 10 shown in Figure 1 represents an operating state, in which the internal combustion engine 12 of the vehicle is turned off. The gearbox arrangement 10 comprises a gearbox input shaft 14, which is coupled with the internal combustion engine 12 via a cardan shaft 16. The gearbox arrangement 10 comprises a main gearbox part 18, in which the switching gearbox of the vehicle not shown in more detail is arranged. A first gearbox section 20, in which the differential gearbox of the vehicle is arranged, is arranged

on the housing of the main gearbox part 18. A second gearbox section 22 holds the power take-off gearbox of the vehicle.

Both in the main gearbox part 18 and also in the two gearbox sections 20, 22 there is lubricant 24. In the turned-off state of the internal combustion engine 12, the lubricant level in the gearbox arrangement 10 is balanced, see here Figure 1. This is achieved by means of the connecting channel 26, which is arranged in the base region of the gearbox arrangement 10 and which connects the main gearbox part 18 separated airtight relative to the two gearbox sections 20, 22 to the two gearbox sections 20, 22.

Figure 2 shows the gearbox arrangement 10 in a state, in which the internal combustion engine 12 is turned on. Accordingly, the gearbox input shaft 14 is driven via the cardan shaft 16. In this way, the air pump 28 is driven, which feeds air from the two gearbox sections 20, 22 into the main gearbox part 18. In this way, in the main gearbox part 18 an overpressure is generated, which forces the lubricant 24 through the connecting channel 26 into the two gearbox sections 20, 22. Accordingly, the lubricant level in the main gearbox part 18 drops nearly completely; in contrast, in the two gearbox sections 20, 22, the lubricant level rises significantly according to the volume ratios. The lubricant pump 30 suctions lubricant 24 via the suction channel 32 and continuously feeds lubricant 24 via the lubricant supply channel 34 to the gearbox parts not shown in more detail in the main gearbox section 18. In this respect, in the main gearbox part 18, practically no splashing losses occur.

In an enlarged side view, Figure 3 shows the two gearbox sections 20, 22, with the lubricant level in the two gearbox sections 20, 22 corresponding essentially to that from Figure 2. The input shaft 36 turns the differential ring gear 38 in the gearbox section 20 in the operating state shown in Figure 3 at a low rpm. The differential ring gear 38 is immersed nearly up to halfway in lubricant 24 for the lubricant level shown in Figure 3, which would lead to high splashing losses for high rpm values of the differential ring gear 38. The differential ring gear 38 throws some lubricant 24 in the tangential direction diagonally upwards, which is indicated with arrow 40.

Figure 4 shows the two gearbox sections 20, 22 in an operating state of the vehicle, for which the differential ring gear 38 turns at an increased rpm. The differential ring gear 38 now throws significantly more lubricant 24 in the tangential direction diagonally upwards, which is indicated with arrow 40. The lubricant 24 thrown upwards is reflected on the upper housing wall and guided into the gearbox section 22. Accordingly, the splashing losses in the gearbox section 20 are nearly negligible for this operating state of the vehicle. This is achieved in that, according to the invention, separating means 42 are provided, which are arranged between the gearbox section 20 and the gearbox section 22. With the separating means 42, the two gearbox sections 20, 22 can be partially separated from each other, whereby lubricant 24 can then be retained in the gearbox housing part 44 of the gearbox

section 22 when the differential ring gear 38 of the gearbox section 20 in the gearbox housing part 46 turns at a high rpm.

Figure 5 shows the two gearbox sections 20, 22 in another operating state of the vehicle. In this operating state, the differential ring gear 38 turns at a low rpm, in other words, the driving speed of the vehicle is less than approximately 15 km/h. In contrast, the power take-off gearbox in the gearbox housing part 44 turns at a high rpm, so that the lubricant 24 is thrown from the gearbox section 22 into the gearbox section 20, that is, basically according to the same principle of immersing a rotating gear, which initially throws the lubricant 24 diagonally upwards to the upper housing wall of the gearbox arrangement 10, where it is deflected into the gearbox section 20. In this respect, the splashing losses in this operating state of the vehicle are nearly negligible in the gearbox section 22, wherein the splashing losses of the differential gearbox - if present at all - are in a low loss range. Although the gears immersed in the lubricant 24 viewed by themselves would throw a portion of the lubricant 24 vertically upwards and accordingly the lubricant 24 would not be led into the gearbox section 20, the lubricant 24 is nevertheless guided diagonally in the direction of the gearbox section 20, because for an active power take-off mode, a not-shown lubricant cooling device for the power take-off shaft coupling 48 is activated, and the lubricant 24 flowing through the power take-off shaft coupling 48 has a horizontal component in the direction of the gearbox section 20, here see the arrows 49 from Figure 7. In this way, due to the superposition of the vertical lubricant throw-off direction - indicated by arrow 51 - on one hand and the horizontal lubricant throw-off direction on the other hand, overall a diagonally upwards lubricant component is produced. The feeding effect according to arrow 51 does not come from the gear, which is shown in Figure 7 and rotates in this view to the right, and with which the coupling drum of the power take-off shaft coupling 48 is connected, because this gear does not project down into the lubricant sump. Instead, the feeding effect comes from a not-shown gear, which meshes with this gear and which is arranged coaxial to the power take-off output shaft 70.

Figure 6 shows the two gearbox sections 20, 22 in a plan view. Here, it can be seen that the separating means 42 extend into an area in the gearbox section 20, which is designated with the reference symbol 50. In this way, the volume available for retaining the lubricant 24 in the gearbox section 22 is increased. This is also visible in Figure 7, wherein here the differential ring gear 38 of the gearbox section 20, as well as individual gearbox parts of the power take-off gearbox of the gearbox section 22 are shown in perspective only schematically. In Figures 6 and 7, the bearing plate 52 of the gearbox section 22 is shown, which is produced in the form of a cast part, which supports the front bearing positions of the power take-off gearbox. The separating means 42 are set on and screwed to this bearing plate 52.

A spring steel strip 54 is attached to the separating means 42 with attachment means 56, for example, rivets, which can be taken from Figure 8. The separating means 42 are in turn attached to the bearing plate 52 with the screw 58. In this state, the spring steel strip 54 is pressed against a diagonal connecting piece 60 on the gearbox housing wall. Here, the gearbox sections 20, 22 for the lubricant 24 can be separated from each other in a sealed way, wherein, in an advantageous way, production-specific, more or less severe deformations of the cast or sheet-metal parts, which contact the spring steel strip 54, can be compensated.

From Figures 3-5 it follows that the separating means 42 extend from the base of the gearbox arrangement 10 up to above the drive shaft 62 for the power take-off gearbox. Here, the drive shaft 62 for the power take-off gearbox could extend through the separating means 42, wherein a sealing means would be provided, which has an effect comparable to the bearing 64, with which effect the drive shaft 62 would then be sealed relative to the separating means 42. However, Figure 7 shows a region 65, in which the separating means 42 extend only up to below the drive shaft 62 of the power take-off gearbox. Accordingly, the separating means 42 must not have any sealing means at this position.

In Figures 3-7, the guidance means 66 are indicated, which are configured in the form of a guidance plate. With the guidance means 66, the feeding effect of the differential ring gear 38 is increased, so that for an operation of the differential gearbox at a high rpm, the feeding of the lubricant 24 into the gearbox section 22 is optimized.

In the area of the gearbox arrangement 10 close to the base, return means 68, which in particular are produced in the form of a bore with a diameter of ca. 8 mm, are provided in the separating means 42. This can be seen, for example, in Figures 1, 2, and 7. In this way, a dynamic lubricant level control is guaranteed, at a high driving speed the lubricant 24 is displaced from the gearbox section 20 into the gearbox section 22 and therefore the splashing losses of the rotating differential ring gear 38 are significantly reduced. But at low driving speeds, the lubricant level is not significantly affected, because the low quantity of thrown lubricant 24 can flow without trouble from the gearbox section 22 into the gearbox section 20, see arrow 69 from Figure 2.

If the power take-off shaft 70 is active - this is typically the case only at driving speeds up to 15 km/h - another advantage is realized, in that now the feeding effect of the rotating gear mechanism of the power take-off gearbox reduces the lubricant level in the gearbox section 22 relative to the state, as shown, for example, in Figures 1 and 3, and in this way the power losses of the power take-off gearbox are reduced.

The gearbox arrangement 10 according to the invention is also effective in extreme operating modes of a tractor, especially for an extreme inclined position, as well as operation for a greatly reduced lubricant filling. This also applies when external loads - for example, hydraulically driven work devices - take lubricant 24 from the gearbox arrangement 10 and in this way the lubricant level is reduced overall.